

WHAT IS CLAIMED IS:

1. A tunneling magnetoresistive element comprising a multilayer film comprising an antiferromagnetic layer, a pinned magnetic layer formed in contact with the antiferromagnetic layer so that the magnetization direction is pinned by an exchange coupling magnetic field with the antiferromagnetic layer, and a free magnetic layer formed on the pinned magnetic layer with an insulating barrier layer provided therebetween, electrode layers formed above and below the multilayer film, insulating layers formed on both sides of the multilayer film in the track width direction, and domain control layers respectively formed on the insulating layers so as to contact at least portions of both end surfaces of the free magnetic layer, for orienting the magnetization direction of the free magnetic layer in a direction crossing the magnetization direction of the pinned magnetic layer;

wherein the domain control layers are formed so as not to extend to the upper surface of the multilayer film.

2. A tunneling magnetoresistive element according to Claim 1, wherein an under laying layer is formed below each of the domain control layers, for controlling crystal orientation of the domain control layers.

3. A tunneling magnetoresistive element according to

Claim 1, wherein each of the domain control layers comprises a hard magnetic material.

4. A tunneling magnetoresistive element according to Claim 1, wherein each of the domain control layers comprises a laminated film of a ferromagnetic layer and a second antiferromagnetic layer, the ferromagnetic layers being in contact with at least portions of both side surfaces of the free magnetic layer.

5. A tunneling magnetoresistive element according to Claim 1, wherein each of the insulating layers comprises an antiferromagnetic insulating layer exhibiting an antiferromagnetic property, and each of the domain control layers comprises a ferromagnetic layer.

6. A tunneling magnetoresistive element according to Claim 4, wherein the second antiferromagnetic layer is made of α -Fe₂O₃.

7. A tunneling magnetoresistive element according to Claim 5, wherein the antiferromagnetic insulating layer is made of α -Fe₂O₃.

8. A tunneling magnetoresistive element comprising a multilayer film comprising an antiferromagnetic layer, a pinned magnetic layer formed in contact with the

antiferromagnetic layer so that the magnetization direction is pinned by an exchange coupling magnetic field with the antiferromagnetic layer, a free magnetic layer formed on the pinned magnetic layer with an insulating barrier layer provided therebetween, electrode layers formed above and below the multilayer film, insulating layers formed on both sides of the multilayer film in the track width direction, and domain control layers formed on the insulating layers so as to contact portions of both side surfaces of at least the free magnetic layer, for orienting the magnetization direction of the free magnetic layer in a direction crossing the magnetization direction of the pinned magnetic layer;

wherein the multilayer film comprises a central sensitive zone having excellent reproducing sensitivity so that a magnetoresistive effect can be substantially exhibited, and dead zones formed on both sides of the sensitive zone and having low reproducing sensitivity so that the magnetoresistive effect cannot be substantially exhibited; and

the domain control layers are formed so as to extend on the dead zones of the multilayer film.

9. A tunneling magnetoresistive element according to Claim 8, wherein an under laying layer is formed below each of the domain control layers, for controlling crystal orientation of the domain control layers.

10. A tunneling magnetoresistive element according to
Claim 8, wherein each of the domain control layers comprises
a hard magnetic material.

11. A tunneling magnetoresistive element according to
Claim 8, wherein each of the domain control layers comprises
a laminated film of a ferromagnetic layer and a second
antiferromagnetic layer, the ferromagnetic layers being in
contact with at least portions of both side surfaces of the
free magnetic layer.

12. A tunneling magnetoresistive element according to
Claim 8, wherein each of the insulating layers comprises an
antiferromagnetic insulating layer exhibiting an
antiferromagnetic property, and each of the domain control
layers comprises a ferromagnetic layer.

13. A tunneling magnetoresistive element according to
Claim 11, wherein the second antiferromagnetic layer is made
of α -Fe₂O₃.

14. A tunneling magnetoresistive element according to
Claim 12, wherein the antiferromagnetic insulating layer is
made of α -Fe₂O₃.

15. A tunneling magnetoresistive element comprising a
multilayer film comprising a free magnetic layer, a pinned

magnetic layer formed on the free magnetic layer with an insulating barrier layer provided therebetween, and an antiferromagnetic layer formed on the pinned magnetic layer, for pinning the magnetization direction of the pinned magnetic layer by an exchange coupling magnetic field, electrode layers formed above and below the multilayer film, domain control layers formed on both sides of the multilayer film in the track width direction so as to contact at least portions of both side surfaces of the free magnetic layer, for orienting the magnetization direction of the free magnetic layer in a direction crossing the magnetization direction of the pinned magnetic layer, and insulating layers formed on the domain control layers; wherein the insulating layers are formed so as not to extend to the upper surface of the multilayer film.

16. A tunneling magnetoresistive element according to Claim 15, wherein an under laying layer is formed below each of the domain control layers, for controlling crystal orientation of the domain control layers.

17. A tunneling magnetoresistive element according to Claim 15, wherein each of the domain control layers comprises a hard magnetic material.

18. A tunneling magnetoresistive element according to Claim 15, wherein each of the domain control layers

comprises a laminated film of a ferromagnetic layer and a second antiferromagnetic layer, the ferromagnetic layers being in contact with at least portions of both side surfaces of the free magnetic layer.

19. A tunneling magnetoresistive element according to Claim 15, wherein each of the insulating layers comprises an antiferromagnetic insulating layer exhibiting an antiferromagnetic property, and each of the domain control layers comprises a ferromagnetic layer.

20. A tunneling magnetoresistive element according to Claim 18, wherein the second antiferromagnetic layer is made of α -Fe₂O₃.

21. A tunneling magnetoresistive element according to Claim 19, wherein the antiferromagnetic insulating layer is made of α -Fe₂O₃.

22. A tunneling magnetoresistive element comprising a multilayer film comprising a free magnetic layer, a pinned magnetic layer formed on the free magnetic layer with an insulating barrier layer provided therebetween, and an antiferromagnetic layer formed on the pinned magnetic layer, for pinning the magnetization direction of the pinned magnetic layer by an exchange coupling magnetic field, electrode layers formed above and below the multilayer film,

domain control layers formed on both sides of the multilayer film in the track width direction so as to contact portions of both side surfaces of at least the free magnetic layer, for orienting the magnetization direction of the free magnetic layer in a direction crossing the magnetization direction of the pinned magnetic layer, and insulating layers formed on the domain control layers;

wherein the multilayer film comprises a central sensitive zone having excellent reproducing sensitivity so that a magnetoresistive effect can be substantially exhibited, and dead zones formed on both sides of the sensitive zone and having poor reproduction sensitivity so that the magnetoresistive effect cannot be substantially exhibited; and

the insulating layers are formed so as to extend on the dead zones of the multilayer film.

23. A tunneling magnetoresistive element according to Claim 22, wherein an under laying layer is formed below each of the domain control layers, for controlling crystal orientation of the domain control layers.

24. A tunneling magnetoresistive element according to Claim 22, wherein each of the domain control layers comprise a hard magnetic material.

25. A tunneling magnetoresistive element according to

Claim 22, wherein each of the domain control layers comprises a laminated film of a ferromagnetic layer and a second antiferromagnetic layer, the ferromagnetic layers being in contact with at least portions of both side surfaces of the free magnetic layer.

26. A tunneling magnetoresistive element according to Claim 22, wherein each of the insulating layers comprises an antiferromagnetic insulating layer exhibiting an antiferromagnetic property, and each of the domain control layers comprises a ferromagnetic layer.

27. A tunneling magnetoresistive element according to Claim 25, wherein the second antiferromagnetic layer is made of α -Fe₂O₃.

28. A tunneling magnetoresistive element according to Claim 16, wherein the antiferromagnetic insulating layer is made of α -Fe₂O₃.

29. A method of manufacturing a tunneling magnetoresistive element comprising:

(a) the step of forming an electrode layer on a substrate, and then laminating an antiferromagnetic layer, a pinned magnetic layer in which magnetization is pinned in a predetermined direction by an exchange coupling magnetic field with the antiferromagnetic layer, an insulating

barrier layer, and a free magnetic layer in turn from the bottom to form a multilayer film;

(b) the step of forming, on the multilayer film, a lift-off resist layer having a notched portion formed on the lower side thereof;

(c) the step of removing both sides of the multilayer film leaving at least a portion of the multilayer film below the resist layer;

(d) the step of forming insulating layers on both sides of the multilayer film so that the multilayer film-side ends of the upper surfaces of the insulating layers are lower than both ends of the upper surface of the free magnetic layer;

(e) the step of forming domain control layers on the insulating layers by sputtering obliquely to the substrate so that the domain control layers contact both ends of the free magnetic layer, and the multilayer film-side ends of the domain control layers coincide with the both ends of the top of the multilayer film; and

(f) the step of removing the resist layer, and forming an electrode layer on the multilayer film and the domain control layers.

30. A method of manufacturing a tunneling magnetoresistive element according to Claim 29, wherein an under laying layer is formed below each of the domain control layers, for controlling crystal orientation of the

domain control layers.

31. A method of manufacturing a tunneling magnetoresistive element according to Claim 29, wherein in the step (d), the insulating layers or the domain control layers are formed by sputtering vertically to the substrate.

32. A method of manufacturing a tunneling magnetoresistive element according to Claim 29, wherein each of the domain control layers comprises a hard magnetic material.

33. A method of manufacturing a tunneling magnetoresistive element according to Claim 29, wherein each of the domain control layers comprises a laminated film of a ferromagnetic layer and a second antiferromagnetic layer, the ferromagnetic layers being in contact with at least portions of both side surfaces of the free magnetic layer.

34. A method of manufacturing a tunneling magnetoresistive element according to Claim 29, wherein each of the insulating layers comprises an antiferromagnetic insulating layer exhibiting an antiferromagnetic property, and each of the domain control layers comprises a ferromagnetic layer.

35. A method of manufacturing a tunneling

magnetoresistive element according to Claim 29, wherein the second antiferromagnetic layer is made of α -Fe₂O₃.

36. A method of manufacturing a tunneling magnetoresistive element according to Claim 33, wherein the antiferromagnetic insulating layer exhibiting antiferromagnetism is made of α -Fe₂O₃.

37. A method of manufacturing a tunneling magnetoresistive element comprising:

(g) the step of forming an electrode layer on a substrate, and then laminating an antiferromagnetic layer, a pinned magnetic layer in which magnetization is pinned in a predetermined direction by an exchange coupling magnetic field with the antiferromagnetic layer, an insulating barrier layer and a free magnetic layer in turn from the bottom to form a multilayer film;

(h) the step of forming, on a sensitive zone of the multilayer film, a lift-off resist layer having a notched portion formed on the lower side thereof;

(i) the step of removing both sides of the multilayer film leaving at least a portion of the multilayer film below the resist layer;

(j) the step of forming insulating layers on both sides of the multilayer film so that the multilayer film-side ends of the upper surfaces of the insulating layers are lower than both ends of the upper surface of the free magnetic

layer;

(k) the step of forming domain control layers on the insulating layers by sputtering obliquely to the substrate so that the domain control layers contact both ends of the free magnetic layer, and extend on dead zones of the multilayer film; and

(l) the step of removing the resist layer, and forming an electrode layer on the multilayer film and the domain control layers.

38. A method of manufacturing a tunneling magnetoresistive element according to Claim 37, wherein an under laying layer is formed below each of the domain control layers, for controlling crystal orientation of the domain control layers.

39. A method of manufacturing a tunneling magnetoresistive element according to Claim 37, wherein in the step (j), the insulating layers or the domain control layers are formed by sputtering vertically to the substrate.

40. A method of manufacturing a tunneling magnetoresistive element according to Claim 37, wherein each of the domain control layers comprises a hard magnetic material.

41. A method of manufacturing a tunneling

magnetoresistive element according to Claim 37, wherein each of the domain control layers comprises a laminated film of a ferromagnetic layer and a second antiferromagnetic layer, the ferromagnetic layers being in contact with at least portions of both side surfaces of the free magnetic layer.

42. A method of manufacturing a tunneling magnetoresistive element according to Claim 37, wherein each of the insulating layers comprises an antiferromagnetic insulating layer exhibiting an antiferromagnetic property, and each of the domain control layers comprises a ferromagnetic layer.

43. A method of manufacturing a tunneling magnetoresistive element according to Claim 41, wherein the second antiferromagnetic layer is made of $\alpha\text{-Fe}_2\text{O}_3$.

44. A method of manufacturing a tunneling magnetoresistive element according to Claim 42, wherein the antiferromagnetic insulating layer exhibiting antiferromagnetism is made of $\alpha\text{-Fe}_2\text{O}_3$.

45. A method of manufacturing a tunneling magnetoresistive element comprising:

(m) the step of forming an electrode layer on a substrate, and then laminating a free magnetic layer, an insulating barrier layer, a pinned magnetic layer, and an

antiferromagnetic layer for pinning magnetization of the pinned magnetic layer in a predetermined direction by an exchange coupling magnetic field in turn from the bottom to form a multilayer film;

(n) the step of forming, on the multilayer film, a lift-off resist layer having a notched portion formed on the lower side thereof;

(o) the step of removing both sides of the multilayer film leaving a portion of the multilayer film below the resist layer;

(p) the step of forming domain control layers on both sides of the multilayer film so that the multilayer film-side ends contact at least portions of both ends of the free magnetic layer;

(q) the step of forming insulating layers on the domain control layers by sputtering obliquely to the multilayer film so that the multilayer film-side ends of the upper surfaces of the insulating layers coincide with both ends of the upper surface of the multilayer film; and

(r) the step of removing the resist layer, and forming an electrode layer on the multilayer film and the insulating layers.

46. A method of manufacturing a tunneling magnetoresistive element according to Claim 45, wherein an under laying layer is formed below each of the domain control layers, for controlling crystal orientation of the

domain control layers.

47. A method of manufacturing a tunneling magnetoresistive element according to Claim 45, wherein in the step (p), the insulating layers or the domain control layers are formed by sputtering vertically to the substrate.

48. A method of manufacturing a tunneling magnetoresistive element according to Claim 45, wherein each of the domain control layers comprises a hard magnetic material.

49. A method of manufacturing a tunneling magnetoresistive element according to Claim 45, wherein each of the domain control layers comprises a laminated film of a ferromagnetic layer and a second antiferromagnetic layer, the ferromagnetic layers being in contact with at least portions of both side surfaces of the free magnetic layer.

50. A method of manufacturing a tunneling magnetoresistive element according to Claim 45, wherein each of the insulating layers comprises an antiferromagnetic insulating layer exhibiting an antiferromagnetic property, and each of the domain control layers comprises a ferromagnetic layer.

51. A method of manufacturing a tunneling

magnetoresistive element according to Claim 49, wherein the second antiferromagnetic layer is made of $\alpha\text{-Fe}_2\text{O}_3$.

52. A method of manufacturing a tunneling magnetoresistive element according to Claim 50, wherein the antiferromagnetic insulating layer exhibiting antiferromagnetism is made of $\alpha\text{-Fe}_2\text{O}_3$.

53. A method of manufacturing a tunneling magnetoresistive element comprising:

(s) the step of forming an electrode layer on a substrate, and then laminating a free magnetic layer, an insulating barrier layer, a pinned magnetic layer, and an antiferromagnetic layer for pinning magnetization of the pinned magnetic layer in a predetermined direction by an exchange coupling magnetic field in turn from the bottom to form a multilayer film;

(t) the step of forming, on a sensitive zone of the multilayer film, a lift-off resist layer having a notched portion formed on the lower side thereof;

(u) the step of removing both sides of the multilayer film leaving at least a portion of the multilayer film below the resist layer;

(v) the step of forming domain control layers on both sides of the multilayer film so that the multilayer film-side ends contact at least portions of both ends of the free magnetic layer;

(w) the step of forming insulating layers on the domain control layers by sputtering obliquely to the multilayer film so that the insulating layers extend on dead zones of the multilayer film; and

(x) the step of removing the resist layer, and forming an electrode layer on the multilayer film and the insulating layers.

54. A method of manufacturing a tunneling magnetoresistive element according to Claim 53, wherein an under laying layer is formed below each of the domain control layers, for controlling crystal orientation of the domain control layers.

55. A method of manufacturing a tunneling magnetoresistive element according to Claim 53, wherein in the step (v), the insulating layers or the domain control layers are formed by sputtering vertically to the substrate.

56. A method of manufacturing a tunneling magnetoresistive element according to Claim 53, wherein each of the domain control layers comprises a hard magnetic material.

57. A method of manufacturing a tunneling magnetoresistive element according to Claim 53, wherein each of the domain control layers comprises a laminated film of a

ferromagnetic layer and a second antiferromagnetic layer, the ferromagnetic layers being in contact with at least portions of both side surfaces of the free magnetic layer.

58. A method of manufacturing a tunneling magnetoresistive element according to Claim 53, wherein each of the insulating layers comprises an antiferromagnetic insulating layer exhibiting an antiferromagnetic property, and each of the domain control layers comprises a ferromagnetic layer.

59. A method of manufacturing a tunneling magnetoresistive element according to Claim 57, wherein the second antiferromagnetic layer is made of $\alpha\text{-Fe}_2\text{O}_3$.

60. A method of manufacturing a tunneling magnetoresistive element according to Claim 58, wherein the antiferromagnetic insulating layer exhibiting antiferromagnetism is made of $\alpha\text{-Fe}_2\text{O}_3$.